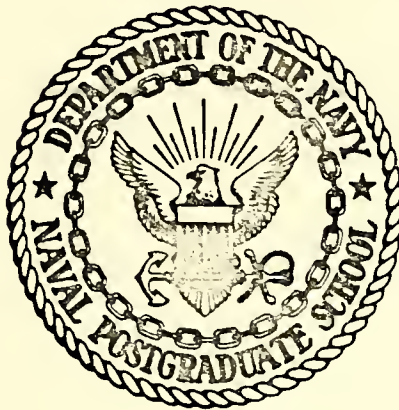AN INVESTIGATION OF VARIABLE
OPERATING AND SAFETY LEVEL (VOSL)
STOCKING AND FUNDING POLICY

Richard Earl Lewis

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN INVESTIGATION OF
VARIABLE OPERATING AND SAFETY LEVEL (VOSL)
STOCKING AND FUNDING POLICY

by

Richard Earl Lewis

and

Robert Darol Perkins

Thesis Advisor: D.A. Schrady

March 1974

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Variable Operating and Safety Level (VOSL)
Stocking and Funding Policy

by

Richard Earl Lewis
Lieutenant Commander, Supply Corps, United States Navy
B.S., University of Idaho, 1965

and

Robert Darol Perkins
Lieutenant Commander, Supply Corps, United States Navy
B.S., Texas College of Arts and Industries, 1960

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Control in the management of stocks of retail material
(DSA) at Navy stock points is exercised through a centrally
administered stocking policy model (VOSL) and funding
policy. The dynamic behavior of these controls operating on
a stock point was investigated by computer simulation. The
simulation results indicate that under the most favorable
circumstances, the value of resupply orders directed by the
VOSL stocking model exceeded the grants made by the funding
policy. Under less favorable, more realistic conditions,
the difference between funding requirements and funding
grants is more marked and supply performance degrades very
significantly over time. The funding dilemma investigated
in this study is well known to Navy stock points and they
have devised various ways of attempting to deal with it.
Significantly, even in a climate of insufficient funding,
system stocking policies (VOSL) provide better performance
than locally devised policies.

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I. INTRODUCTION

A. BACKGROUND

With the establishment of the Defense Supply Agency (DSA) wholesale operation, it was no longer possible for the Navy to maintain large quantities of backup stocks. However to maintain the desired levels of fleet support, a new scientific inventory management program for the various stock points was essential. This ultimately resulted in the Variable Operating and Safety Level - Requisitions Short Model (VOSL-RSM) for inventory control and the Financial Management (funding) policy in use today for 9-COG items.

The basic VOSL model was designed to find a trade off between concentrating investment in the high dollar demand categories or in the low dollar demand categories. Stated another way, the model finds a trade off between sales and line item effectiveness. The model was also constrained to allow a maximum of 2.5 months of stock on hand. This 2.5 months of stock on hand was composed of two parts. The first part, α, represents the portion of the inventory supporting demands while the second part, $(2.5 - \alpha)$, represents the portion of the inventory allocated as safety stock. The requisitions short modification to the original VOSL model seeks to improve requisition effectiveness by allocating the funds available for investment in safety stock.

This thesis investigates the adequacy of the stocking and funding policies from the users' point of view; the users

being stock points. Personal contact and discussion with a West Coast stock point (hereafter referred to as Stock Point A) concerning problems they were experiencing with VOSL-RSM provided the initial motivation for this study. Additional informal contact with several other stock points enhanced this motivation and provided strong indications that VOSL-RSM is not always operating as the stock points would desire.

One of the initial steps of this study was to obtain from the Fleet Material Support Office (FMSO) a Master Stock Point Record (MSPR) tape for Stock Point A dated January 1973. A random sample of 864 line items on this tape indicated a zero on hand balance for 50.7 percent of the sample. The on order position for these items could not be determined with any degree of accuracy since in many cases this data position on the tape was either zero filled or there was really nothing on order. In either event, some problem was clearly evident. Stock Point A indicated that their stock position had not significantly improved since the date of the MSPR tape, because sufficient funds were not available to utilize the optimal order quantities generated by VOSL-RSM. Thus, they were forced to constrain the value of inventory resupply requisitions in order to operate within funding limits; i.e., they had to ignore both the VOSL rules and the VOSL ANALYZER and invent their own rules. For example, some stock points have:

  (1) placed a monetary limit of ten dollars on resupply
       requisitions

(2)   set order quantities to be equal to 30 days of forecasted demand

(3)   set reorder points to zero

(4)   modified stocking and replenishment criteria to stock and order only those items having at least six demands in six months.

Contact with people at the working level at Stock Point A revealed two widely separated views concerning the source/cause of the problem. On one side, the financial management people argue that since funds are granted on a sales replacement basis an efficiently functioning stock control branch should be able to operate normally within the funding limitations. This argument ignores such factors as large increases in quantity of demand, increases in lead time, inflation, and bad buys. The last factor, bad buys, are unavoidable in most cases and can be a real crippler even when countered with a super aggressive excessing policy. Unless a stock point is fortunate enough to have a clairvoyant stock control officer who can predict demand on individual line items with complete certainty, the bad buy problem can only get worse.

To return to the other side of the house, the stock control people contend that funds are never adequate and when funds are reduced for any reason, the on hand stock position is degraded. This ultimately will reduce sales and correspondingly reduce the funds available for stock replacement. The arguments offered by both sides reflect the opinions most often heard in support or defense of any inventory/funding policy. Although the arguments of both sides have

some merit they are by no means a mutually exclusive, collectively exhaustive set.

B. EXISTING SYSTEM

The existing system for the management of 9-COG items is comprised of two basic policies; a stocking policy and a funding policy.

1. Stocking Policy

The stocking policy considered in this study is the existing VOSL model discussed in Ref. 1 which operates on a 2.5 month average investment level constraint. This model divides the inventory of a stock point into ten classes according to value of annual demand. The value of annual demand configuration determines the average operating level investment, α, and enables the model to compute optimal order quantities, q's. The "Requisitions Short" capability is provided by the modification to the basic VOSL model discussed in Ref. 2. This modification utilizes the previously determined α and allocates the remaining investment $(2.5 - \alpha)$ in safety stocks. This allocation is accomplished on an item by item basis and considers unit cost, frequency, order quantity, demand forecast and risk of stockout. After the safety level investment allocations are made, safety levels and reorder points are computed.

In actual operation of the VOSL-RSM there are two basic portions of the program with the first portion managed and operated by FMSO, and the second portion operated by the individual stock points. Initially the FMSO portion of the

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VOSL program begins with a value of annual demand (VAD) listing which is a list of stock points' entire active inventory ordered in terms of VAD from highest to lowest. The program divides the stock points' inventory into ten classes according to VAD and determines an appropriate multiplier, λ', as discussed in Appendix B. The individual stock points then take this information provided by FMSO as inputs to their portion of the VOSL program. Their program places each individual item in its appropriate VAD class and computes optimal order quantities, safety levels and reorder points which the stock point requires for operation.

2. Funding Policy

The VOSL funding policy, as described in Ref. 3, is based on a moving average of the previous four quarters of issues, months of active stock on hand, fiscal year to date (FYTD) issues, FYTD funding and a draw-down policy for material in a long supply status. These items provide the necessary information to compute a recommended quarterly fund grant.

C. PROBLEM AREAS

There are numerous potential and/or existing problem areas in the current system. For example, the stocking policy is based on an average two and one-half month stock investment while the funding policy is based on the sales of the prior years. This seems to ve a very loose connection. It should also be noted that both the VOSL-RSM stocking

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policy and the existing funding policy are rather rigid and
little if any allowance is made for (1) changing demand
patterns, (2) inflation, (3) bad buys, (4) increased lead
times; etc. Specifically for (1) and (4), both funding and
stocking the models react or adapt, but only in a painfully
slow, after-the-fact manner. That is, in a tight money
situation, if demand begins to increase there will not be
sufficient funds to stock quantities to support the new
requirement. Thus, sales will not be made, and, consequently,
no increase in funding will be recieved, the following
quarter. The standard rebuttal to this type argument is
that the increased demand for some items will be offset by
reduced demands for other items and things tend to even out
in the long run. A sequence of factors as described above
could (and, in fact, does) place the stock points in an
increasingly untenable situation with respect to their
inventory positions. In addition funding inflexibility has
driven stock points to invent and implement their own
stocking replenishment rules - ignoring both VOSL and the
VOSL ANALYZER.

D. STUDY OBJECTIVES

The primary hypothesis of this study is that the
existing VOSL-RSM stocking policy used in conjunction with
the existing funding policy will not operate as designed in
a dynamic "real world" environment. The secondary hypothesis
is that the inventory position and effectiveness measures of

a stock point using a local, less than optimal, stocking policy will be much worse than following VOSL-RSM rules even in a climate of insufficient funds.

Specifically, the objectives of this study are to:

(1) determine if the current funding policy for 9-COG items provides sufficient funds to allow the VOSL-RSM stocking policy to operate as planned;

(2) determine the effects on funding, effectiveness, etc. when the stock point is limited to the use of actual funds granted when using optimal VOSL-RSM stocking policy; and

(3) repeat (2) using a locally constrained stocking policy instead of the VOSL-RSM stocking policy

The general method of achieving the study objectives will be by means of computer simulations designed to reflect the daily operation of a stock point over a period of ten years. The stock point operations to be simulated include not only the daily receipt and issue of materials, but also an excessing program, migration of items from an inactive to active status and vice versa, increases in unit prices due to inflation, and the stock points' portion of the VOSL-RSM stocking policy calculations. In addition the FMSO portion of VOSL-RSM stocking policy and funding calculations are included in the simulation. Underlying this was the desire to demonstrate such phenomena as the direction and orders of magnitude of performance indicators over time.

II. MODEL

A. DATA

As previously indicated, the initializing data for all
simulation runs was "real world" data obtained from the MSPR
tape dated January 1973 of stock point A's. A computer
program was written to dump the entire contents of the tape,
relative to the first 3,400 9-COG items, in order to deter-
mine which data elements would be useful. This was necessary
since some data elements were known to be filled with either
blanks or zeros. As a result of this determination, the
data fields selected for use in the simulation were (1) on
hand quantity, (2) quantity of demand during the previous
four quarters, (3) frequency of demand during the previous
four quarters, (4) unit price, (5) Mean Absolute Deviation
(MAD) of demand, and (6) lead time. It was decided
arbitrarily that a sample of 300 items from the tape would
be sufficient for simulation purposes. Thus for each simu-
lation run a uniformly distributed random sample was drawn
from the 3,400 items on the tape by means of a uniform
discrete random number generator initialized by a different
random number seed for each run. The seeds were selected
at random from a table of random numbers.

The six data elements for each of the 300 items selected
for a simulation run were used to initialize and compute all
required data for the simulations. Unit price, demand and
frequency were used to establish initial stocking and

funding policies. The demand and MAD elements were utilized
to establish the Stuttering Poisson distribution, which was
used, as discussed in Appendix A, to generate ten years of
demand history. The lead time was used to arrive at a
measure of number of back-orders, number of back-order days,
and to set reorder points.

B. GENERAL DESCRIPTION OF MODEL

The simulation model initially selects 300 numbers at
random, uniformly distributed between one and 3,400. The
six data elements for each 9-COG item on the MSPR tape
corresponding to the 300 selected numbers were read from the
tape and stored in one of two working matrices; i.e.,
matrix IDATA for integer data and matrix DATA for decimal
data. Since there is a positive probability that the
uniform discrete random number generator may generate
duplicate numbers, the actual number of items selected was
somewhat smaller than 300 but was never smaller than 287
items. At this point one-third of the items previously
selected were again subjected to a random, uniform selection
to be coded as items of active stock. The remaining two-
thirds of the items were held in reserve and coded as
not-carried items.

The value of annual demand for all items coded active
was then calculated and optimal order quantities for each
item were calculated in the parameters calculation subroutine
(Subroutine PARAM) under the guidelines of Ref. 1. Safety

levels were then calculated in the safety level computation
routine (Subroutine SAFLEV) under the guidelines of Ref. 2.
See Appendix B for a discussion of the method of calculating
safety levels using λ'.

At this point, a critical assumption of constant lead
time was made to facilitate the rapid calculation of reorder
points. Contact with the stock point whose data was on the
MSPR tape indicated that the lead time data element of the
tape contained the most recent lead time experienced by each
item. It is that value that was used for the lead time in
the simulations.

The next step of the simulation was to calculate the
recommended, quarterly VOSL program funding in the funding
subroutine (Subroutine BUCKS) under the guidelines of Ref.
3. Since funding is based on dollar value of issues, it
was also assumed that the dollar value of demands equals the
dollar value of issues. This assumption was applied only to
the first four quarters of the simulation since demands and
issues were recorded separately once the simulation began.
A decision was also made at this point to calculate dollars
of fund reduction due to long supply based on the percentage
method of Ref. 3 rather than by Stratification.

Recent observations of stock point A indicates that
approximately ten percent of their total number of carried
items become inactive due to declining demands over a year's
time, and approximately the same number of not-carried items
qualify for stocking. Based on this observation, at the

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beginning of each simulation year, ten percent of the active
items were selected to become inactive over the course of
the year. Again a random uniform selection as to which
quarter of the year each item would become inactive was
made, and at the first of the selected quarter, demand was
set equal to zero. A similar procedure was followed to
select a like number of not-carried items to begin experi-
encing demand during the selected quarter of the year.

The simulation then used the Stuttering Poisson distri-
bution as a vehicle to calculate time until next demand and
quantity of next demand. The use of the Stuttering Poisson
is a major assumption which ultimately means that the times
between demands are independent, identically distributed as
the exponential distribution, and that the quantity demanded
is distributed geometrically. Two artificialities were
introduced into the simulation; first, time to next demand
was constrained to be greater than or equal to one day and
second, quantity of demand was constrained to integer values
between one and ten thousand to eliminate unrealistically
high demands.

In as much as the data elements of the MSPR tape
indicated that the inventory position of the majority of
the items was less than optimal; the program was designed
to allow the user the choice of (1) bringing the inventory
position to a point between the reorder point and the
requisition objective, or (2) leaving the inventory position
"as is" to begin the simulation. This is accomplished by

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the insertion/removal of the card calling Subroutine REORDR in the main program. The user of the program also has the option of utilizing the calculated VOSL optimal order quantity, or constraining the order quantity to any desired level by the insertion/removal of cards in the issue subroutine (Subroutine DISSU).

One additional assumption was made concerning unit price of the items. It was assumed that all items were standard stock to be processed at standard price; however, in order to approximate more closely the current economic environment, unit price was increased 2.5 percent the first day of each quarter. The figure of 2.5 percent is based on the current government cost of capital and inflation which is approximately ten percent annually. It is recognized that an increase in unit price of 2.5 percent applied quarterly, biases the annual percentage rate upwards from 10 percent to approximately 10.4 percent. This is not significantly different from the real world situation of fluctuating inflation. However, in the analysis of the simulation results, one can not consider the absolute value of dollar differences alone, but must also consider the percentage of difference between ten year totals of funds vs. sales. These percentages should remain stable since the inflation increases were applied on a constant basis.

In the day to day simulation of ten years of operation the following three principles were used:

1. When a demand is processed, resupply, if required, is initiated immediately, and when an outstanding resupply order is received, outstanding backorders are filled immediately.
2. Receipts are always processed before demands when they occur on the same day.
3. The ten years of simulation are ma   on the premise of 30 day months, 91 day quarters and 364 day years.

At this point the 10 year simulation began by comparing the earliest event time where an event was considered to be a demand or receipt of a resupply order. The earliest event was processed in either the receipt of a resupply requisition subroutine (Subroutine RECPT) or the issue subroutine. In Subroutine RECPT, the receipt of the outstanding resupply order was processed, outstanding backorders, when existing, were filled and on hand stock position was updated. In Subroutine DISSUE the demands for stock were filled or back-ordered if the on hand balance was insufficient to meet the demand. Time and quantity of next demand were updated for the item which had completed processing of the current demand and a resupply order was generated when necessary. Two assumptions which were made should be noted at this point. First, there are no lost sales since partial issues are made when the quantity of demand exceeds on hand balance and the unfilled portion of the quantity demanded is placed on backorder. Some exceptions to this assumption were made for the second, third, fourth and fifth type runs discussed in the following section. The assumption was relaxed when and if, on a quarterly basis, the point was reached where the dollar value of the backorder would exceed the remaining

balance of funds available. The items which would have been treated as backorders in this case were counted as lost sales. The second assumption was that stock replenishments were to be computed as multiples of the computed economic VOSL order quantity, q^*. A multiplier of q^* (an integer value constrained between zero and two hundred) was determined in order to insure that the inventory position was increased to a point between the reorder point and the requisition objective when a resupply action was necessary.

After processing the earliest event in the applicable subroutine, control was returned to the main program where the determination of the next earliest event time was made. A check was made to determine if the current earliest time places the simulation in the next quarter of the year and/or the next simulation year. When the next quarter was reached, Subroutine ENDQTR was called to compute the fund grant for the following quarter, update the changes required in the active/inactive items and compute the value of excess stock on hand. Two additional assumptions were made at this point. First, for items scheduled to be coded inactive, the quantity of demand was set to zero at day one of the quarter in which the item becomes inactive. The on hand quantity was maintained "as is" for three quarters of a year before being set to zero during the fourth quarter of being coded inactive. The rationale behind this time span was obtained from Stock Point A where, in their estimation, it takes two quarters of zero demand to recognize an inactive item;

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another quarter to declare the item excess, process required paper work and receive disposition instructions; and sometime in the following (fourth) quarter the stock is removed from inventory. It must be noted that there was no reimbursement of funds to the stock point for excessed items made in the simulation. Based on point A's information concerning reimbursement as a percentage of the inventory value of items excessed and the dollar value of items actually excessed in the simulation there would be no significant effect on the results of the simulation. The second assumption was that when an active coded item did not experience sufficient demand and frequency to remain active, the item was considered to fall in the insurance item category and remained in the inventory as an active item. This assumption appears to be valid since ten percent of the inventory has previously been coded to become inactive during the year (based on the estimate of Stock Point A) and a perusal of the simulation results indicate that an insignificant number of items with low dollar value fall in the insurance item category in any year.

At the end of each simulation year, parameters were recomputed based on the actual simulation issues and demands of the previous four quarters, and a new fund grant was computed for the simulation to continue into the next year.

C. DESCRIPTION OF TRIALS

Five basic types of simulations were run with each type being run three times with different random number seeds to provide results for different data samples.

The first type simulation run was designated "VOSL-RSM OPTIMAL" since all calculations were made optimally as per the guidelines of Refs. 1, 2, and 3. This type run does not attempt to approximate actual happenings at a stock point but attempts to determine what would happen if orders were placed at the appropriate times and for the optimal quantities without being limited by a budget constraint. This is an implicit assumption that if and when additional funds are required for stock replenishment; the additional funds are made available. In as much as the inventory position obtained from the MSPR tape is not optimal, the inventory position was reset to a point between the reorder point and the requisition objective before beginning the time step through the ten years of simulated operation. During the course of the ten years simulated operation, all calculations related to stocking and funding policies were made optimally. The significant points in this type simulation, as in all other types of simulations run, are (1) an inflation factor which increases unit price 2.5% on day one of each quarter, (2) an excessing policy which approximates the current policy in use at Stock Point A, (3) constant lead times, and (4) the use of the STUTTERING POISSON distribution to compute times and quantities of demand. At the completion of ten years of simulated operation, various statistics and data were printed for analysis and comparison.

The second type simulation run was designated "VOSL-RSM MODIFIED". This type run was identical to the first type

except for the following three modifications: (1) the dollar value of resupply orders placed each quarter was constrained to be less than or equal to the available funds, (2) the demand was treated as a lost sale, if and when, in any quarter, there were insufficient funds available to backorder stock to meet an existing demand, and (3) surplus funds were expended on resupply orders if and when surplus funds were available on the last day of the quarter. The significant points as discussed for the first type run remained the same for this type run. At the completion of ten years of simulated operation various statistics and data were again printed for analysis and comparison.

The third type simulation run was designated "MOD" since optimal VOSL stocking policies were not used; however, the method of calculating funds under the VOSL system was maintained. This type run was designed to represent an approximate model of the general policies used at Stock Point A; thus, the inventory position at the beginning of the simulation remained exactly as shown on the MSPR tape. The modifications to the optimal policies for this type run were: (1) resupply orders were constrained in quantity to provide a maximum inventory position of thirty days forecasted demand, (2) the demand was treated as a lost sale if and when, in any quarter, there were insufficient funds available to back- order stock to meet an existing demand, (3) resupply orders were generated only when the inventory position of any item was found to be less than or equal to zero, (4) the surplus

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funds were expended on resupply orders if and when, in any quarter, surplus funds were available on the last day of the quarter, and (5) the dollar value of resupply orders placed each quarter was constrained to be less than or equal to available funds. Again the significant points discussed for the first type run remained the same, and at the end of ten years simulated operation, statistics and data were printed for analysis.

The fourth type of simulation run was designated "MOD2". This run was identical to the third type run (MOD) with the exception that the inventory position at the beginning of the simulation run was placed at a point between the reorder point and the requisition objective prior to beginning the time step portion of the run; i.e., there was an initial fix. Everything else in this type run was exactly the same as in the third type run.

The fifth and final type of simulation run was designated "VOSL-RSM MOD2". This run was identical to the second type run (VOSL-RSM MODIFIED) with the exception that the inventory position at the beginning of the simulation run remained exactly as shown on the MSPR tape; i.e., no initial fix. Everything else in this type run was exactly the same as the second type run.

The purpose of the initial fix or initial order to correct inventory position deficiencies was to determine if the one-time expenditure of funds made any significant difference in the end results of the simulations.

FEATURE	TYPE OF RUN				
	VOSL–RSM OPTIMAL	VOSL–RSM MODIFIED	MOD	MOD2	VOSL–RSM MOD2
INFLATION	yes	yes	yes	yes	yes
FUND CONSTRAINT	no	yes	yes	yes	yes
INITIAL ORDER	yes	yes	no	yes	no
VOSL RULES	yes	yes	no	no	yes
POINT A RULES	no	no	yes	yes	no
BACKORDERS	yes	yes	yes	yes	yes
LOST SALES	no	yes	yes	yes	yes

III. ANALYSIS OF SIMULATION RESULTS

Before beginning any type of analysis it seems proper to briefly review the salient points common to all types of simulation runs. These points are:

(1) Constant lead time for each item; however, the lead times are uniformly distributed about the mean due to Stock Point A's procedure of recording most recently observed lead time for each item on the MSPR tape.

(2) Stuttering Poisson process for generating time and quantity of next demand, which implies a constant mean rate of demand over the ten year simulation.

(3) A reasonable excessing policy based on actual practice at Stock Point A.

(4) A fixed inflation factor of 2.5% which increases unit price on a quarterly basis and thus affects both issues and resupply orders.

The results of the five types of simulations described in the previous section are now discussed in turn.

A. VOSL-RSM OPTIMAL

The VOSL-RSM OPTIMAL simulation was designed to determine if the optimal stocking and funding policies are compatible under ideal conditions. This required the dollar value of orders to be unconstrained by funds, but the value of orders versus funds would be compared at the end of the simulation. In addition, this type simulation also provided a base line as to what effectiveness and work load should be under ideal conditions. These measures were:

(1) total number of backorders,

(2) total number of backorder days, and

(3) total number of resupply orders.

The simulation results for the three different inventory samples used in the VOSL-RSM OPTIMAL type simulations showed that, in each case, the value of resupply orders exceeded funds generated. On the average, fund grants were 96.2% of the value of resupply orders and the range of this difference was from 95.1% to 96.8%.

It is recognized that the percentage difference between funds and resupply orders is small, however, any increase in lead times, demand rates, inflation or a less aggressive excessing policy would serve to increase the difference. Even though the percentage difference seems small the magnitude of the difference, which was $17,141, must also be investigated.

Since both the stocking and funding policies operate on the premise of 2.5 months of stock on hand, the value of the on hand inventory can be approximated by calculating the average monthly value of issues (approximately equal to the value of monthly demands for this type simulation) and then multiplying this figure by 2.5 months. This value was calculated to be $9,238. Thus the percentage of difference which initially seemed quite small takes on more significance, and it is clear from the above calculations that the magnitude of the difference represents a value equivalent to a loss of 185.5% of the value of on hand inventory. The range of this loss for the three stock samples was from 154% to 245%. It must be recognized that the small percentage difference or shortfall in fund grants is somewhat misleading.

This is because orders were placed optimally at all times and in the quantities appropriate without regard to available funds. This produced additional on-hand stock which would not have been available under a fund constraint and this additional stock in turn provided the base for increased sales. The increased issues then generated increases in fund grants. Even with this ultra optimistic approach there was still a short fall in fund grants. Recognize also that there is no real loss of inventory, but rather a quantitative measure of the short fall in fund grants.

B. VOSL-RSM MODIFIED

Since the additional funds which would be required to operate the VOSL-RSM OPTIMAL simulation model would not normally be available, the VOSL-RSM MODIFIED simulation was run to determine the effect of constrained funding. This was accomplished by changing the VOSL-RSM OPTIMAL simulation to include the additional constraint that on a quarterly basis, the dollar value of resupply orders must be less than or equal to the dollar value of available funds. The results of this simulation indicated that:

(1) The average funding of the VOSL-RSM MODIFIED simulation was equal to 86.2% of the VOSL-RSM OPTIMAL funding. This 13.8% reduction in fund grants from the VOSL-RSM OPTIMAL simulation is the result of constraining dollar value of resupply orders to be less than or equal to the quarterly fund grants.

This constraint reduced on-hand inventory which in
turn reduced sales. The reduced sales then reduced
the following quarters fund grants and the cycle of
events repeats itself.

(2) Expected number of backorders increased by 62.6%.

(3) Expected number of backorder days increased by 76.4%.

(4) Expected number of stock control type transactions
(processing resupply orders plus lost sales)
increased by 49.4%. Lost sales were added to orders
for determining the increase in transactions, since
in the real world supply system the lost sale to
VOSL-RSM must still be processed as a direct purchase
or passed to another supply activity. Thus a lost
sale does increase the work load of the stock control
branch.

C. MOD

The third type simulation, designated MOD, approximates
the stocking policy in use at Stock Point A and was run to
determine the effects of operating under a rather severe
factoring of optimal stocking policies. For this type
simulation, initial inventory position at the start of the
simulation remained as shown on the MSPR tape and there was
no initial inventory fix. On a quarterly basis dollar value
of resupply orders was constrained to be less than or equal
to available funds, and resupply orders were constrained in
quantity to allow a maximum inventory position equal to
30 days forecasted demand. In addition, resupply orders

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were generated only when inventory position became less than
or equal to zero. This is equivalent to a zero reorder
point and a negative safety level. The results of this
simulation were compared to the VOSL-RSM OPTIMAL simulation
results and showed that:

(1)   Average funding was reduced to 68.6% of VOSL-RSM
      OPTIMAL funding. The severe reduction of funds was
      primarily due to the initial inventory position in
      which stock was unavailable for issue; thus there
      was a reduction in issues, which reduced funds, which
      reduced inventory, etc. With the ultimate end being
      a drastic reduction in funds.

(2)   Expected number of backorders increased by 376.4%.

(3)   Expected number of backorder days increased by 354%.

(4)   Expected number of stock control type transactions
      increased by 401.4%.

D.   MOD2

The fourth type simulation run, designated MOD2, was
designed to correspond directly to the second type simulation
(VOSL-RSM MODIFIED) in order to determine the effects of a
factored stocking policy. MOD2 is identical to VOSL-RSM
MODIFIED with the exception of the stocking policy which was
as described for the third type simulation (MOD). In
addition, the MOD2 run serves to indicate what would happen
if Stock Point A were allowed additional funds in order to
bring the existing inventory position to a point between the

reorder point and requisition objective while continuing
to operate under their current stocking policy.

The results of this type run indicate that the use of
the factored stocking policy had the following effects when
compared to VOSL-RSM MODIFIED simulation results:

(1) Average funding increased to 104.4% of VOSL-RSM
     MODIFIED funding. The average funding increased,
     because fewer dollars were being placed into inventory
     by smaller q's and r's for items for which demand
     declined. Thus the loss due to "bad buys" was
     reduced. Also, due to the policy of negative safety
     level, more backorders were generated. This caused
     more issues to take place in a quarter following the
     resupply order. Thus, the issue was processed at a
     price higher than the resupply cost, increasing issues,
     fund grants, etc.

(2) Expected number of backorders increased 239.1%.

(3) Expected number of backorder days increased 221.0%.

(4) Expected number of stock control type transactions
     increased 400.5%.

The results of the MOD2 run were also compared to the
type three (MOD) simulation to determine the effect of a
one-time fund grant used to place the inventory in an
optimal position before beginning the simulation. The
results of this comparison between the MOD and MOD2 runs
are as follows:

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(1) Average funding increased to 131.2% of MOD funding. This increase is primarily due to the increased initial inventory position which allowed more issues, increased fund grants, etc.

(2) Expected number of backorders decreased to 81.6% of MOD. This decrease in backorders and backorder days resulted because the initial inventory position fix was utilized to meet demands while available funds were utilized to replenish the on-hand inventory.

(3) Expected number of backorder days decreased to 85.9% of MOD.

(4) Expected number of stock control type transactions increased to 119.4% of MOD. The stock control transactions increased, because the additional funds generated by the increased initial inventory allowed placement of additional orders which, in turn, generated more funds, etc.

E. VOSL-RSM MOD2

The fifth type simulation, designated VOSL-RSM MOD2, was designed to investigate what would happen at Stock Point A if the initial inventory position were not changed from that indicated in the MSPR tape and a VOSL-RSM optimal stocking policy was utilized. This simulation was identical to the second type simulation (VOSL-RSM MODIFIED) except that the initial inventory position was not changed. The results of this simulation were compared with the third type

simulation (MOD) to contrast the difference in the two stocking policies. The results of this comparison are:

(1) Funding decreased to 89.1% of MOD funding. The funds decreased because the VOSL-RSM operates on a requisition effectiveness premise and minimizes all costs which include holding and ordering. Thus, funds are invested in high demand fast moving items, and not necessarily the high dollar value items. But most importantly there was no initial fix to allow more sales and thus generate more funds.

(2) Expected number of backorders decreased to 31.7% of MOD. This decline in backorders and backorder days is due to the basic purpose of the VOSL-RSM model. That is, to minimize the probability of requisitions short.

(3) Expected number of backorder days decreased to 37.2% of MOD.

(4) Expected number of stock control type transactions decreased to 44.3% of MOD.

IV. SUMMARY AND CONCLUSIONS

The computer simulations used in this study attempted to model a very complex, dynamic inventory control system. As is the case with most simulations, short cuts and approximations of reality were used when necessary to reduce computer time. Consequently, one should consider the numerical results of the simulations and analysis on an order-of-magnitude basis only.

The analysis of the results of the VOSL-RSM OPTIMAL simulation runs supports the hypothesis that the existing stocking and funding policies are not operating as designed. Acceptance of this hypothesis in no way constitutes a criticism of either the VOSL-RSM inventory model or the 9-COG funding policy on an individual basis. In fact, when considered separately, the two policies seem to be well grounded theoretically and present a rational approach to solving an extremely complex real world problem. However, when the two policies are mated there is strong evidence from both the results of this simulation as well as from information obtained via informal contacts with several major stock points that there is indeed a significant problem when the two policies are considered collectively.

For example, the three different inventory samples used in the VOSL-RSM OPTIMAL type simulation each showed that fund grants were insufficient to meet the value of the optimal resupply orders. In fact, the difference after

ten years of simulated operations was equivalent to 154% of the value of average on-hand inventory.

The secondary hypothesis, that the inventory position and effectiveness measures of a stock point using local, less than optimal, stocking policies will be much worse than when following VOSL-RSM rules even in an insufficient funds climate, has been well supported by the simulation results. However, the perspective from which one views the results is most critical on this point. For example, a very restrictive locally devised stocking criteria in which only high demand fast moving items are stocked keeps a stock point's net effectiveness high. But this policy does poorly in generating funds. The end result is that net effectiveness looks good while service as perceived by the customer is degraded due to longer waiting times for the not-carried slower moving items.

The simulation results also indicate that when a stock point significantly reduces optimal order quantities and uses a restricted inventory position there is an increase in fund grants. This is caused by the slight increase in sales resulting from small stocks of slower moving items. However, backorders and the internal workload of the stock point increase rapidly when using this type policy.

Since the results of this simulation verify the stock point's contention that funds are insufficient for optimal operation, there is a direct implication that the stock points are forced to operate inefficiently in order to

survive in the short run. This has led to a situation in
which the individual stock points ignore or modify VOSL-RSM
as they see fit. Thus, system wide, there exists large
disparities in stocking criteria, replenishment critera,
etc. The tragedy of this situation is that these locally
devised criteria in many cases operate in direct, but
unknowing, opposition to system goals.

Perhaps the admirable "CAN DO" attitude and spirit of
the Navy is catching up with the times, for the fix, patch
and make do routines can only be carried on to some point.
Maybe the time has come to attack the politically unpalatable
problems of proving the Navy needs more funds to combat
inflation, bad buys, etc. It is time to face the problems
and fight them intelligently with arguments based on sound
judgement and objective quantitative analyses.

APPENDIX A. THE STUTTERING POISSON PROCESS

It is assumed that $\{N_i(t), t \geq 0\}$ is a Poisson process and that $\{Y_{in}, n=1,2,\ldots, N_i(t)\}$ is a family of independent, identically distributed geometric random variables with probability mass function

$$P_Y(y) = \begin{cases} p(1-p)^{y-1} & \text{for } y = 1,2,\ldots\ldots \\ 0 & \text{elsewhere.} \end{cases}$$

Let Y_{in} be the quantity of item i demanded on requisition n and let $N_i(t)$ be the number of requisitions received up to time t. Additionally, let $X_i(t)$ be the total quantity of item i demanded up to time t. Thus

$$X_i(t) = \sum_{n=1}^{N_i(t)} Y_{in} \quad .$$

The time between arrivals of requisitions for item i is an exponentially distributed random variable, due to the Poisson process assumption, with density function

$$f_T(t) = \begin{cases} \lambda_i e^{-\lambda_i t} & \text{for } t \geq 0 \\ 0 & \text{elsewhere.} \end{cases}$$

A compound Poisson process such as $\{X_i(t), t \geq 0\}$ where Y_{in} is geometrically distributed is frequently referred to as a STUTTERING POISSON PROCESS [Ref. 4].

From the MSPR tape, mean quarterly demand (DBAR) and mean absolute deviation of quarterly demand (MAD) were obtained for each item. These parameters were then used to estimate the parameters of the Stuttering Poisson demand distribution for each item in the inventory. Since the simulation time-step is one day, the parameters of the exponentially distributed interarrival time for requisitions must also be expressed in days. Thus mean daily demand, μ_i, is

$$\mu_i = \frac{DBAR_i}{91} \qquad (1)$$

The variance of daily demand, $\sigma_i{}^2$ is

$$\sigma_i{}^2 = \frac{1}{91}\left[\frac{MAD_i}{0.8}\right]^2 , \qquad (2)$$

assuming 91 days per quarter and that the standard deviation of quarterly demand is estimated by $MAD_i/0.8$ [Ref. 5].

For a compound Poisson process $\{X_i(t),\ t \geq 0\}$ it can be shown that [Ref. 6]

$$E[X_i(t)] = \lambda_i t\, E[Y_{in}] , \qquad (3)$$

$$VAR[X_i(t)] = \lambda_i t\, E[Y_{in}{}^2] . \qquad (4)$$

Since Y_{in} is distributed geometrically, it follows that, when t is set equal to one day, the equations for the mean

and variance of daily demand, μ_i and σ_i^2, are

$$E[X_i(1)] = \frac{1}{P_i} = \mu_i ,$$
(5)

$$VAR[X_i(1)] = \frac{i(2-P_i)}{P_i^2} = \sigma_i^2$$
(6)

Solving equation (5) yields $\lambda_i = P_i\mu_i$. Substitution of this into equation (6) gives

$$P_i = \frac{2\mu_i}{\sigma_i^2 + \mu_i}$$

and

$$\lambda_i = \frac{2\mu_i^2}{\sigma_i^2 + \mu_i} ,$$

where μ_i and σ_i^2 are given by equations (1) and (2).

Thus, in this manner, the STUTTERING POISSON distribution parameters are computed for each item.

APPENDIX B.   SAFETY LEVEL CALCULATION METHOD

In VOSL-RSM the inventory is constrained to permit an
average on hand investment equal to two and one-half months
of supply. The total inventory is comprised of items
separated into ten sales classes based on the individual
items value of annual demand. In addition the sales class
configuration of the inventory determines the average level
of operating stock investment, α. Then with this α, there
remains $(2.5 - \alpha)$ months of supply which are to be invested
in safety stocks.

The total value of the previous years demands (VADSUM)
may be easily computed and divided by twelve to provide the
estimated or average value of monthly demand. The estimate
of dollars required for safety stock investment (DSLA) then
may be computed by

$$DSLA = (VADSUM/12) \ (2.5 - \alpha)$$

This becomes the funds available for the requisition short
model to allocate in such a manner that requisition effec-
tiveness is maximized.

Reference 2 attacks the problem of the requisitions
short model by means of a risk equation for computation
of risk of stock out. This equation is solved by the method
of Lagrange to obtain

$$P_i = \lambda' \left[\frac{C_i \, Q_i}{F_i} \right] \tag{1}$$

and

$$\lambda' = \frac{\sum\limits_{i=1}^{N} \left[\dfrac{P_i F_i}{Q_i} \right] SL_i}{\left[\dfrac{2.5-\alpha}{3} \right] \sum\limits_{i=1}^{N} C_i \overline{D}_i} , \tag{2}$$

where

λ' = Lagrange Multiplier

P_i = Risk of a stockout for the ith item

C_i = Unit price of the ith item

F_i = Annual frequency of the ith item

$\overline{D}_i$ = Quarterly Demand Forecast for the ith item

Q_i = The order quantity from the VOSL program for the ith item.

SL_i = Safety level in units for the ith item

Since a direct method of solving equations (1) and (2) is not feasible and the iterative method of solution utilized in Ref. 2 is very time consuming on a computer, an estimate of the exact solution was obtained by linear interpolation as follows:

(a) Select two arbitrary values of λ' and designate them
λ'_K ; K=1,2.

(b) Solve equation (1) for all i; K=1,2.

(c) Solve equation (2) in terms of SL_i for all i; K=1,2.

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(d) Compute DL_k, the total dollar requirement for safety level investment using λ'_K, where

$$DL_k = \sum_{i=1}^{N} C_i SL_i \quad ; K=1,2.$$

(e) Compute the linear interpolation estimated solution for λ' where

$$\lambda' = \frac{(DSLA - DL_1)\,(\lambda'_1 - \lambda'_2)}{(DL_1 - DL_2)} + \lambda'_1$$

This method assumes that by virtue of past experience the two arbitrary values of λ' initially selected would bracket the exact solution to equation (2). It should also be noted the linear interpolation method of estimating the solution to equation (2) (which is assumed to be a convex function) will provide a solution value slightly higher than the exact value. This implies a small increase in risk and corresponding small decrease in the safety level dollar investment.

The final step in computing safety levels by this method is to take the estimated solution for λ' and calculate SL_i for each item in the inventory using equation (2).

APPENDIX C. MATRIX TERMINOLOGY

In the computer simulation, two basic working matrices were used for data storage. Matrix IDATA with an individual data position denoted IDATA (i,j) where $i=1,2,...,$ 300 and $j=1,2,...,25$ contained integer data for the ith item of stock. The 25 data positions (j) for the individual items of stock are defined as follows:

j	DEFINITION
1	serial number of VOSL item obtained form MSPR tape
2	quantity on hand
3	quantity due
4	quantity backordered
5	reorder point
6	safety level
7	economic order quantity
8	requisition objective
9	lead time demand
10	VOSL stock class
11	quantity demanded quarter prior
12	quantity demanded 2 quarters prior
13	quantity demanded 3 quarters prior
14	quantity demanded 4 quarters prior
15	frequency of demand quarter prior
16	frequency of demand 2 quarters prior
17	frequency of demand 3 quarters prior
18	frequency of demand 4 quarters prior
19	time of next demand
20	quantity of next demand
21	active/inactive item code
22	total frequency prior year
23	active/inactive quarter code
24	quantity requisitioned for resupply
25	time of receipt of next resupply requisition

Matrix DATA with an individual data position denoted
DATA (i,j) where $i = 1,2,...,300$ and $j=1,2,...,25$ contained
real number data for the ith item of stock. The 25 data
positions (j) for the individual items of stock are defined
as follows:

j	DEFINITION
1	unit price
2	order quantity in months of stock
3	quarterly demand forecast
4	mean absolute deviation of demand (MAD)
5	lead time
6	value on hand inventory
7	value of annual issues
8	the STUTTERING POISSON parameter, V
9	the STUTTERING POISSON parameter, P
10	value of annual demand (VAD)
11	cumulative percent VAD
12	dollar value of quantity ordered
13	total number of backorders per year
14	total number of backorder days per year
15	total number of issues per quarter
16	total number of demands per quarter
17	total number of resupply requisitions per quarter
18	total number of demands processed not carried per quarter
19	total value of demands processed not carried per quarter
20 thru 25	not used for individual item

The position DATA $(2,25)$ was used to maintain a quarterly
running balance of funds.

APPENDIX D

```
************************************
**     TYPE ONE SIMULATION       **
**        VOSL-RSM OPTIMAL        **
************************************
```

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	VALUE INITIAL ORDER
1	621753	642259	636545	1123	31713	2225	8536
2	227213	238848	227872	1438	41853	2827	6473
3	455876	475158	465964	1151	32269	1893	5418
TOTAL	1304842	1356265	1330381	3712	105835	6945	20427
AVERAGE	434947	452088	443460	1237	35278	2315	6809

```
*******************************
**    TYPE TWO SIMULATION    **
**                           **
**     VOSL-RSM MODIFIED     **
*******************************
```

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	554005	553944	564276	1923	58423	2170	808
2	158444	158406	159283	2439	77022	2919	1392
3	412143	412015	411730	1672	51243	2736	355
TOTAL	1124592	1124365	1135289	6034	186688	7825	2555
AVERAGE	374264	374788	378429	2011	62229	2608	851

NOTE

*** VALUE INITIAL ORDER
****
*** SAME AS VOSL-RSM OPTIMAL

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```
************************
*                      *
* TYPE THREE SIMULATION *
*                      *
*        MOD           *
*                      *
************************
```

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	380345	380327	382829	6362	175015	6362	6879
2	153193	153162	153489	5994	158592	7200	3398
3	361282	361180	366208	5323	146870	8845	2140
TOTAL	894820	894669	902526	17679	480477	22407	12417
AVERAGE	298273	298223	300842	5893	160159	7469	4139

```
***********************
*                     *
*  TYPE FOUR SIMULATION *
*                     *
*       MOD2          *
*                     *
***********************
```

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	570310	565592	579948	5690	147988	12808	1107
2	197887	197282	198212	4536	120200	12810	1386
3	405816	405701	413375	4199	144403	12438	1016
TOTAL	1174013	1172575	1191535	14425	412591	38056	3509
AVERAGE	391337	390858	397178	4808	137530	12685	1169

NOTE

*** VALUE INITIAL ORDER

*** SAME AS VOSL-RSM OPTIMAL

```
************************
*                      *
*  TYPE FIVE SIMULATION *
*                      *
*    VOSL-RSM  MOD 2    *
*                      *
************************
```

RUN NUMBER	FUND GRANT	VALUE ORDERS	VALUE ISSUES	TOTAL BACKORDERS	TOTAL BACKORDER DAYS	TOTAL NUMBER ORDERS	TOTAL LOST SALES
1	327804	327798	329301	1474	47558	1474	6679
2	144039	144021	142971	2386	76336	2386	2013
3	333369	333322	332508	1751	54782	1902	966
TOTAL	805212	805141	804780	5611	178676	5762	9658
AVERAGE	268404	268380	268260	1870	59558	1920	3219

THIS TYPE SIMULATION IS CESIGNATED

VOSL-RSM MODIFIED

```
N=WORLD SAMPLE SIZE
INO=NUMBER OF ACTIVE ITEMS
VAD1=ACTIVE ITEMS BY VAD
VADSUM=VALUE OF ANUAL DEMAND
VISS=FYTD VALUE OF ANNUAL ISSUES
FGNT=FYTC FUNDS GRANTED
FUND=QUARTERLY OPTAR
DCLORD=VALUE OF ORDERS
JTEST=TIME TILL NEXT DEMAND
ITEST=TIME TILL NEXT RECEIPT
KQTR=QUARTER COUNTER
KYEAR=YEAR COUNTER
SBUCKS=YEAR SUMATION OF FUNDS
YRISS=TOTAL DOLLAR VALUE ISSUES
YRDMD=TOTAL NUMBER DEMANDS
YRORD=TOTAL DOLLAR VALUE ORDERS
YPNISS=TOTAL NUMBER ISSUES
YRFUND=TOTAL DOLLAR VALUE FUNDS
YRBO=TOTAL NUMBER BACKORDERS
YRBOD=TOTAL NUMBER BACKORDER CAYS
YRIBO=TOTAL NUMBER ITEMS THAT HAD BACKCRDERS
YROOD=NUMBER REQUISITIONS PROCESSED(RESUPPLY)
SLOP=YEARLY DEMANDS TREATED LCST SALES
GLOP=VALUE DEMANDS TREATED LOST SALES
```

CCCCC

```
C     DIMENSION ARRAYS AND SET CONSTANTS
      DIMENSION IREC(62)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION IRND(300)
      DIMENSION SP(4),PSP(4),QMC(10),VX(4),SM(10),AREA(10),TAREA(10),VAD
     1(10),VMD(10),VAD1(10),DLLS(10)
      DIMENSION POINT(150,3)
      DIMENSION IPNX(300)
      DIMENSION RND(300)
      DIMENSION IOQTY(300,8)
      DIMENSION AVISS(4)
      DATA QMC/1.0,1.5,2.0,2.5,3.0,4.C,5.0,6.0,8.0,12.0/
      LCW=1
      LHI=3400
      JKCOUNT=0
      JKCUNT=0
      N=300
      KYR=1
      ITIME=1
      IX1=63741151
      IX2=21465003
      IX3=81001999
      IX4=35352667
      IX5=74377741
      EXCZ=0
      YRISS=0.00
      YRDMD=0.00
      YRCRD=0.00
      YRNISS=0.00
      YRFUND=0.0
      YRBCD=0.00
      YRIBQ=0.00
      YRCOD=0.00
      DO 29 I=1,N
      DO 30 J=1,8
      IOQTY(I,J)=0.0
   30 CONTINUE
   29 CONTINUE
```

CCCCC

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```
C     SELECT A UNIFORMLY DISTRIBUTED
C          RANDOM DATA SAMPLE
C          AND SORT INTO NUMERICAL ORDER

      CALL SELECT(LOW,LHI,N,IX1,IRND)
      DO 10 I=1,N
      IRNX(I)=I
      RND(I)=FLOAT(IRND(I))
   10 CONTINUE
      CALL SHSORT(RND,IRNX,N)

C     READ THE SELECTED DATA SAMPLE
C          FROM THE MSPR TAPE

1111  READ (1,900) IREC
 900  FORMAT (8X,I6,6X,I10,18X,I1,27X,I8,4I6,18X,2I9,6X,5I6,I3,4X,9I6,9I
     13,12X)
      IF(IREC(3).EQ.1) GO TO 2222
      GO TO 1111
2222  IKOUNT=IKOUNT+1
      DO 6111 J=1,N
      IF(IKOUNT.EQ.RND(J))GO TO 3333
6111  CONTINUE
      GO TO 1111
3333  JKOUNT=JKOUNT+1
      IDATA(JKOUNT,1)=IKOUNT
      IDATA(JKOUNT,2)=IREC(4)
      IDATA(JKOUNT,3)=0
      IDATA(JKOUNT,4)=0
      IDATA(JKOUNT,21)=0
      IDATA(JKOUNT,23)=0
      DATA(JKOUNT,12)=0.0
      IDATA(JKOUNT,24)=0.0
      IDATA(JKOUNT,25)=9999
      DATA(JKOUNT,1)=IREC(2)*0.01
      DATA(JKOUNT,2)=IREC(3)*0.01
      DATA(JKOUNT,4)=IREC(10)*0.01
      DATA(JKOUNT,5)=IREC(16)*0.1
      DATA(JKOUNT,11)=0.0
      DO 6112 J=1,4
```

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```fortran
      K=10+J
      KK=22-J
      IDATA(JKOUNT,K)=IREC(KK)
      L=14+J
      LL=31-J
      IDATA(JKOUNT,L)=IREC(LL)
 6112 CONTINUE
      IF(IKOUNT.EQ.RND(N)) GO TO 4444
      GO TO 1111
 4444 INC=JKOUNT/3
      N=JKOUNT
C
C          SELECT THE ITEMS TO BE CODED ACTIVE
C
      CALL SELECT(LOW,JKOUNT,INO,IX2,IRNC)
      DO 6113 I=1,INO
      IKE=IRND(I)
      IDATA(IKE,21)=1
 6113 CONTINUE
      ISL=0
      DO 8888 I=1,N
      IF(IDATA(I,21).EQ.1) ISL=ISL+1
 8888 CONTINUE
      INO=ISL
C
C          THIS MARKS THE BEGINNING CF EACH
C                 SIMULATION YEAR
C
  129 DO 33 I=1,N
      DATA(I,13)=0.0
      DATA(I,14)=0.0
      VADI(I)=0.0
   33 CONTINUE
      SEUCKS=0.0
      SUMDA=0.0
      SUMBO=0.0
      EXCZ=0.0
```

```
C     COMPUTE VALUE OF ANNUAL DEMAND
C          FOR ALL ACTIVE ITEMS

      CALL AVAD(IDATA,DATA,N,VAD1,VADSUM)
      IF(KYR.GT.1) GO TO 6978
      DO 1199 KL=1,4
      AVISS(KL)=VADSUM/4.0
1199  CONTINUE
6978  WRITE(6,4501) VADSUM
4501  FORMAT(' ','VADSUM',F10.3)
      KLINK=INO
      IFINK=0
      DO 98 I=1,N
      IF(VAD1(I).GT.0) IFINK=IFINK+1
98    CONTINUE
      INO=IFINK
      DO 6114 I=1,INO
      IRND(I)=I
6114  CONTINUE
      CALL SHSORT(VAD1,IRND,INO)
      DO 6115 I=1,INO
      K=INO-I+1
      L=I-1
      POINT(I,1)=VAD1(K)
      IF(I.EQ.1) GO TO 6116
      POINT(I,2)=POINT(L,2)+POINT(I,1)
      POINT(I,3)=POINT(I,2)/VADSUM
      GO TO 6115
6116  POINT(I,2)=POINT(I,1)
      POINT(I,3)=POINT(I,2)/VADSUM
6115  CONTINUE

C              COMPUTE PARAMETERS

      CALL PARAM(POINT,QMC,VADSUM,INO,SM,ALADJ)
      INO=KLINK
      DO 6117 I=1,N
      DO 6118 K=1,10
      KAT=K
      IF(DATA(I,10).GT.SM(K)) GO TO 6119
6118  CONTINUE
6119  IDATA(I,10)=KAT
```

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```
      DATA(I,2)=GMC(KAT)
      DATA(I,3)=(DATA(I,10)/DATA(I,1))/4
      IDATA(I,7)=((DATA(I,3)/3)*(DATA(I,2))+0.5)
      IF(IDATA(I,7).LE.1) IDATA(I,7)=1
      IDATA(I,9)=(DATA(I,3)/3)*(DATA(I,5))
      DATA(I,6)=IDATA(I,3)*DATA(I,1)
      DATA(I,7)=DATA(I,10)
      IF(DATA(I,3).EQ.0.0) DATA(I,3)=1.0
6117  CONTINUE

C     COMPUTE SAFETY LEVEL

      CALL SAFLEV(IDATA,CATA,VADSUM,ALADJ,N)
      VISS=0.0
      FGNT=0.0
      VADSUM=AVISS(1)+AVISS(2)+AVISS(3)+AVISS(4)

C     COMPUTE QUARTERLY FUND GRANT

      CALL BUCKS(DATA,IDATA,VADSUM,N,VISS,FGNT,FUND)
      FGNT=FUND
      SBUCKS=SBUCKS+FGNT
      CALL INOUT(IDATA,N,IX4,IX5,INO)
      IF(KYR.GT.1) GO TO 229
      DC 6120 I=1,N
      AMU=DATA(I,3)/91
      SIGSQ=((DATA(I,4)/0.8)**2)/91
      DATA(I,8)=(2*(AMU**2))/(SIGSQ+AMU)
      DATA(I,9)=(2*AMU)/(SIGSQ+AMU)
      IF(DATA(I,9).GE.1.0) DATA(I,9)=0.99
      IF(DATA(I,9).LE.0.0) DATA(I,9)=0.01
      IX2=IX2*65539
      AA=0.5+IX2*0.2328306E-9
      IDATA(I,19)=ALOG(AA)/(-DATA(I,8))
      IF(IDATA(I,19).LE.0) GO TO 6122
      GC TO 6121
6122  IDATA(I,19)=1
6121  IX3=IX3*65539
      AB=0.5+IX3*0.2328306E-9
      IDATA(I,20)=ALOG(AB)/ALOG(1-DATA(I,9))
      IF(IDATA(I,20).GE.10000) GO TO 6121
      IF(IDATA(I,20).LE.0) GO TO 6121
      IF(IDATA(I,21).EQ.2) GO TO 6123
6125  IF(IDATA(I,21).GE.4) GO TO 6124
```

```
6123 GC TO 6120
     IF(IDATA(I,23).EQ.1) GO TO 6124
     GO TO 6120
6124 IDATA(I,19)=9999
6120 CONTINUE

C    RESET INVENTORY PCSITION TO A POINT
C    BETWEEN REORDER POINT AND
C    REQUISITICN OBJECTIVE
C
C    REMOVE CALL CARD IF THIS IS NOT
C                     DESIRED

     CALL REORDR(IDATA,DATA,N,FUND,ITIME,DOLORD)
     YRCRD=YRCRD+DOLORD
     WRITE (6,9010) FUND,DOLORD
9010 FORMAT (' ',F10.2,'FUND=',F10.2,'VALUE ORDERS=',F10.2)
     WRITE (6,9020) ((IDATA(I,J),J=1,25),I=1,JKCLNT)
9020 FORMAT (' ',25I5)
     WRITE (6,9030) ((CATA(I,J),J=1,14),I=1,JKCLNT)
9030 FORMAT (' ',14F8.2)
     WRITE (6,8000) ALADJ
8000 FORMAT (' ',F15.6)
     DO 9111 J=1,10
9111 CCNTINUE
 229 KGTR=1

C    THIS MARKS THE BEGINNING CF EACH
C                  SIMULATICN QUARTER

3350 KKCTR=(91*(KQTR))+((KYR-1)*364)
     AVISS(KQTR)=0.0
     DOLORD=0.0
     DATA(1,25)= 0.0
     DATA(2,25)=FUND
     DATA(3,25)=0.0
     DO 4446 I=1,N
     DATA(I,15)=0.0
     DATA(I,16)=0.0
     DATA(I,17)=0.0
```

53

```
      DATA(I,18)=0.0
      DATA(I,19)=0.0
      DATA(I,1)=1.025*DATA(I,1)
      IF((IDATA(I,21).EQ.1) GO TO 4447
      IF((IDATA(I,21).EQ.2) GO TO 4447
      IF((IDATA(I,21).EQ.4) GO TO 4447
      IF((IDATA(I,21).GE.5) GO TO 4447
      GO TO 4446
4447  IDATA(I,KQTR+10)=0
      IDATA(I,KQTR+14)=0
4446  CONTINUE
C
C         DETERMINE EARLIEST EVENT TIME
C         AND GO TO ISSUE,RECEIPT OR ENC QUARTER
C         ROUTINES AS APPROPRIATE
C
3349  JTEST=9999
      JTEST=9999
      JJJ=0
      III=0
      DO 3340 I=1,N
      IF((IDATA(I,21).EQ.3) GO TO 3340
      IF((IDATA(I,21).EQ.0) GO TO 3340
      IF(JTEST.LE.IDATA(I,19)) GO TO 3342
      JTEST=IDATA(I,19)
      JJJ=I
3341  IF(ITEST.LE.IDATA(I,25)) GO TO 3340
      ITEST=IDATA(I,25)
      III=I
3340  CONTINUE
      KILL=ITEST-JTEST
      IF(KILL.GE.0) GO TO 3344
      IF(KKQTR.GE.ITEST) GO TO 3345
      GO TO 3346
3344  IF(KKQTR.GE.JTEST) GO TO 3347
```

```fortran
C
C     PERFORM END QUARTER HOUSEKEEPING
C          COMPUTATIONS
C
3346  ITIME=KKQTR
      KLIK=0
6     DO 1 I=1,N
      IF(DATA(2,25).LE.5.0) GO TO 7
      IF(IDATA(I,21).EQ.1) GO TO 2
      IF(IDATA(I,21).EQ.2) GO TO 2
      GO TO 1
2     IWAN=IDATA(I,2)+IDATA(2,3)-IDATA(I,4)
      IF(IWAN.LE.KLIK) GO TO 3
      GO TO 1
3     IF(DATA(2,25).GE.DATA(I,1)) GO TO 4
      GO TO 1
4     DOLORD=DOLORD+DATA(I,1)
      DATA(2,25)=DATA(2,25)-DATA(I,1)
      DATA(I,17)=DATA(I,17)+1.0
      IF(IDATA(I,3).EQ.0) GO TO 5
      IDATA(I,3)=IDATA(I,3)+1
      GO TO 1
5     IDATA(I,25)=ITIME+(30.0*DATA(I,5))
      IDATA(I,3)=IDATA(I,3)+1
1     CONTINUE
      IF(KLIK.GT.99) GO TO 7
      KLIK=KLIK+1
      IF(DATA(2,25).GT.5.0) GO TO 6
7     WRITE(6,142) DOLORD,DOLORD
142   FORMAT(' ',' DOLORD',F10.2)
      YRORD=YRORD+DOLORD
1781  SLOP=0.0
      GLOP=0.0
      DO 1782 I=1,N
      SLOP=SLOP+DATA(I,18)
      GLOP=GLOP+(DATA(I,19))
1782  CONTINUE
      WRITE(6,1783) SLOP,GLOP
1783  FORMAT(' ','DUE TO INSUFF FUNDS',F16.2,'ISSUES WERE LOST WHICH WE
     1RE VALUED AT',F16.2)
      IF(KQTR.EQ.4) GO TO 3348
      DO 8813 I=1,N
      DATA(I,6)=IDATA(I,2)*DATA(I,1)
8813  CONTINUE
```

55

```
      CALL ENDQTR(IDATA,DATA,N,SM,QMC,VACSUM,AVISS,FGNT,FUND,VALUE,VISS,
     1KQTR,IX2,IX3,INO,EXCZ,ITIME)
      SBUCKS=SBUCKS+FUND
      DO 2929 I=1,N
      YRNISS=YRNISS+DATA(I,15)
      YFDMD=YRCMD+DATA(I,16)
      YROOD=YROOD+DATA(I,17)
 2929 CONTINUE
      GO TO 3350
C
C                   PERFORM END YEAR HOUSEKEEPING
C                        COMPUTATIONS
 3345 ITIME=ITEST
      CALL RECPT(IDATA,DATA,III,IOQTY,AVISS,KQTR)
      GO TO 3349
 3347 ITIME=JTEST
      CALL DISSU(IDATA,DATA,JJJ,ICQTY,KQTR,ITIME,IX2,IX3,AVISS,DOLORD)
      GO TO 3349
 3348 KYR=KYR+1
      DO 7710 I=1,N
      IF(IDATA(I,21).EQ.0) GO TO 7710
      IF(IDATA(I,21).EQ.1) GO TO 7710
      IF(IDATA(I,21).EQ.2) GO TO 7711
      IF(IDATA(I,21).GE.8) GO TO 7710
      GO TO 7712
 7711 IF(IDATA(I,23).EQ.KQTR) GO TO 7714
      GO TO 7710
 7714 IDATA(I,21)=4
      IDATA(I,19)=9999
      IDATA(I,20)=0
      GO TO 7710
 7712 IDATA(I,21)=IDATA(I,21)+1
      IF(IDATA(I,21).LT.7) GO TO 7710
      EXCZ=EXCZ+(IDATA(I,2)*DATA(I,1))
      IDATA(I,2)=0
      IDATA(I,3)=0
      IDATA(I,4)=0
      IDATA(I,25)=9999
      INO=INO-1
      GO TO 7710
 7713 IF(IDATA(I,23).EQ.KQTR) GO TO 7715
      GO TO 7710
 7715 IX2=IX2*65539
      AAA=0.5+IX2*0.2328306E-9
      IDUM21=ALOG(AAA)/(-DATA(I,8))
      IDATA(I,19)=IDUM21+ITIME
      IF(IDATA(I,19).LE.ITIME) IDATA(I,19)=ITIME+1
```

```
       CCCCC

7716   IDATA(I,21)=1
       IX3=IX3*65539
       AAB=0.5+IX3*0.2328306E-9
       IDATA(I,20)=ALOG(AAB)/ALOG(1-DATA(I,9))
       IF(IDATA(I,20).GE.10000) GO TO 7716
       IF(IDATA(I,20).LE.0) GO TO 7716
7710   CONTINUE
       WRITE(6,118) KQTR,EXCZ
118    FORMAT(' ','EXCESS AT END QTR',I3,3X,'IS',F10.2)

                    PRINT END YEAR RESULTS

9031   WRITE (6,9031) (AVISS(I),I=1,4)
       FORMAT(' ','AVISS',4F10.2)
       YRISS=YRISS+AVISS(1)+AVISS(2)+AVISS(3)+AVISS(4)
       ARIP=0.0
       DO 4329 I=1,N
       YRNISS=YRNISS+DATA(I,15)
       YRDMD=YRDMD+DATA(I,16)
       YROOD=YROOD+DATA(I,17)
       IF(DATA(I,13).GT.0.0) ARIP=ARIP+1
       SUMDA=SUMDA+DATA(I,14)
       SUMBO=SUMBO+DATA(I,13)
4329   CONTINUE
       WRITE(6,2943) SUMBO
2943   FORMAT(' ',' ','TOTAL NUMBER BACKORDERS FOR THE YEAR IS',9X,F10.2)
       WRITE(6,2843) SUMDA
2843   FORMAT(' ',' ','TOTAL NUMBER BACKORDER DAYS FOR THE YEAR IS',F15.2)
       YRFUND=YRFUND+SBUCKS
       YREO=YREO+SUMBO
       YRBOD=YRBOD+SUMDA
       YRIBO=YRIBO+ARIP
       WRITE(6,9050) YRDMD,YRNISS,YROOD
9050   FORMAT(' ',' ','TOTAL NR DMD=',F16.2,'TOTAL NR ISSUES=',F16.2,'TOTAL
      1NR ORDERS=',F16.2)
       WRITE(6,9060) YRFUND,YRORD,YRISS
9060   FORMAT(' ',' ','TOTAL FUND GRANT TO CATA=',F16.2,'TOTAL VALUE ORDERS=
      1',F16.2,'TOTAL VALUE ISSUES=',F16.2)
       WRITE(6,9070) YRIBO,YRBO,YRBOD
9070   FORMAT(' ',' ','TOTAL ITEMS BO=',F16.2,'TOTAL NR BO=',F10.2,'TOTAL BO
      1 DAYS=',F16.2)
       IF(KYR.EQ.11) GO TO 128
       GO TO 129
128    STOP
       END
```

CCCCC

57

```fortran
      SUBROUTINE SELECT(LOW,LHI,N,IX,IRND)
      DIMENSION IRND(300)
      DO 150 I=1,N
      IX=IX*65539
      R=0.5+IX*0.2328306E-9
      IRND(I)=LHI*R+LOW
150   CONTINUE
      RETURN
      END


      SUBROUTINE AVAD(IDATA,DATA,N,VAD1,VADSUM)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION VAD1(150)
      KK=0
      VADSUM=0.0
      DO 101 I=1,N
      ISUM=0
      DO 201 J=1,4
      K=J+10
      ISUM=ISUM+IDATA(I,K)
201   CONTINUE
      DATA(I,10)=ISUM*DATA(I,1)
      IF(IDATA(I,21).EQ.1) GO TO 301
      IF(IDATA(I,21).EQ.2) GO TO 301
      IF(IDATA(I,21).EQ.4) GO TO 301
      IF(IDATA(I,21).EQ.5) GO TO 301
      IF(IDATA(I,21).EQ.6) GO TO 301
      GO TO 101
301   VADSUM=VADSUM+DATA(I,10)
      IF(DATA(I,10).EQ.0.0) GO TO 101
      KK=KK+1
      VAD1(KK)=DATA(I,10)
101   CONTINUE
      RETURN
      END
```

58

```
      SUBROUTINE PARAM(POINT,QMC,CS,INO,SM,ALADJ)
      DIMENSION POINT(150,3)
      DIMENSION SP(4),PSP(4),QMC(10),VX(4),SM(10),AREA(10),TAREA(10),VAD
     1(10),VMD(10),DLLS(10)
      ENCP=FLOAT(INO)
      ALPHA=0.7
      MARK1=INO-3
      MARK2=INO-4
      SP(1)=POINT(4,1)
      SP(2)=POINT(MARK2,1)
      SP(3)=POINT(3,1)
      SP(4)=POINT(MARK1,1)
      PSP(1)=POINT(4,3)
      PSP(2)=POINT(MARK2,3)
      PSP(3)=POINT(3,3)
      PSP(4)=POINT(MARK1,3)
      WRITE (6,4551) (SP(I),I=1,4)
 4551 FORMAT (' ','SP ',F10.3)
      WRITE (6,4552) (PSP(I),I=1,4)
 4552 FORMAT (' ','PSP ',F10.3)
  104 DO 100 K1=1,4
      P1=PSP(K1)
      CALL NDTRI (P1,X,D,IER)
      VX(K1)=X
  100 CONTINUE
      WRITE (6,4553) (VX(I),I=1,4)
 4553 FORMAT (' ','VX ',4F10.3)
      RHO2=(ALOG(SP(4))-ALOG(SP(3)))/(VX(3)-VX(4))
      WRITE (6,4554) RHO2
 4554 FORMAT (' ','RHO2 ',F10.4)
      FLMN2=(VX(2)*ALOG(SP(1))-VX(1)*ALOG(SP(2)))/(VX(2)-VX(1))
      CC=CS/ENCP
      ENLT=6/(EXP((RHO2**2)/8)*SQRT(CD))
      WRITE (6,4555) FLMN2,ENLT
 4555 FORMAT (' ','FLMN2 ',F10.4,'ENLT ',F10.4)
      AQ=ALPHA/ENLT
      DO 200 K2=1,9
      SM(K2)=(6*AQ*((QMC(K2+1)+QMC(K2))/(QMC(K2+1)*QMC(K2)))*2
      WRITE(6,4556)SM(K2)
 4556 FORMAT(' ','SM ',F10.3)
      TEE=(ALOG(SM(K2))-FLMN2)/RHO2
      WRITE (6,4557) TEE
 4557 FORMAT(' ','TEE ',F10.3)
      CALL NDTR(TEE,P2,D)
      AREA(K2)=1-P2
  200 CONTINUE
      SM(10)=0
      TAREA(10)=P2
```

```
      TAREA(1)=AREA(1)
      DO 300 K3=2,9
      TAREA(K3)=AREA(K3)-AREA(K3-1)
  300 CONTINUE
      TVAD=0
      TDLLS=0
      TVMD=0
      DO 400 K4=1,10
      VAD(K4)=TAREA(K4)*CS
      VMD(K4)=VAD(K4)/12
      TVAD=TVAD+VAD(K4)
      TVMD=TVMD+VMD(K4)
      DLLS(K4)=VMD(K4)*(QMC(K4))/2
      TDLLS=TDLLS+DLLS(K4)
  400 CONTINUE
  105 ALADJ=TDLLS*12/CS
      RETURN
      END

      SUBROUTINE SAFLEV(IDATA,DATA,VADSUM,ALADJ,N)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      AMDAA=0.003
      AMDAB=0.009
      DSLA=(2.5-ALADJ)*(VADSUM/12)
      TATA=0.0
      TCTB=0.0
      DO 810 I=1,N
      JSUMF=0
      DO 825 J=15,18
      JSUMF=JSUMF+IDATA(I,J)
  825 CONTINUE
      IF(JSUMF.LE.1) JSUMF=1
      IDATA(I,22)=JSUMF
      IF(IDATA(I,21).EQ.1) GO TO 815
      IF(IDATA(I,21).EQ.2) GO TO 815
      IF(IDATA(I,21).EQ.4) GO TO 815
      IF(IDATA(I,21).EQ.5) GO TO 815
      GO TO 810
  815 RHCA=(AMDAA*DATA(I,1)*IDATA(I,7))/JSUMF
      TA=(AMDAA*(2.5-ALADJ)*(DATA(I,1)**2)*DATA(I,3)*IDATA(I,7))/(3*RHOA
     1*JSUMF)
      TCTA=TCTA+TA
```

```
      RHOB=(AMDAB*DATA(I,1)*IDATA(I,7))/JSUMF
      TB=(AMDAB*(2.5-ALADJ)*(DATA(I,1)**2)*DATA(I,3)*IDATA(I,7))/(3*RHOB
     1*JSUMF)
      TOTB=TOTB+TB
 810  CONTINUE
      ZOOM=DSLA-TOTB
      IF(ZOOM.EQ.0.0) ZOOM=1.0
      ZAAM=TOTA-TOTB
      IF(ZAAM.EQ.0.0) ZAAM=1.0
      AMDAC=(ZOOM*(AMDAA-AMDAB)/ZAAM)+AMDAB
      WRITE (6,811) AMDAC
 811  FORMAT (' ', AMDAC', F10.6)
 820  DO 835 I=1,N
 840  RHOC=(AMDAC*DATA(I,1)*IDATA(I,7))/IDATA(I,22))
      IDATA(I,6)=(AMDAC*(2.5-ALADJ)*DATA(I,1)*DATA(I,3)*IDATA(I,7))/(3*R
     1HOC*IDATA(I,22))
      IF(IDATA(I,6).LE.0) GO TO 845
      GO TO 850
 845  IDATA(I,6)=0
      IDATA(I,5)=IDATA(I,6)+IDATA(I,9)
 850  IDATA(I,8)=IDATA(I,6)+IDATA(I,7)
 835  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BUCKS(DATA,IDATA,VALUE,N,VISS,FGNT,FUND)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      IVAL=0
      DO 500 I=1,N
      IF(IDATA(I,21).EQ.1) GO TO 515
      IF(IDATA(I,21).EQ.2) GO TO 515
      IF(IDATA(I,21).EQ.4) GO TO 515
      IF(IDATA(I,21).EQ.5) GO TO 515
510   IF(IDATA(I,21).EQ.6) GO TO 515
      GO TO 500
515   IVAL=IVAL+DATA(I,6)
500   CONTINUE
      TEST=((12*IVAL)/VALUE)-2.5
      IF(TEST.LT.0.49) GO TO 516
      IF(TEST.LT.1.49) GO TO 517
      IF(TEST.LT.1.99) GO TO 518
      IF(TEST.LT.2.49) GO TO 519
      IF(TEST.LT.2.99) GO TO 520
      IF(TEST.LT.3.49) GO TO 521
      CENT=0.21
      GO TO 523
516   CENT=0.00
      GO TO 523
517   CENT=0.03
      GO TO 523
518   CENT=0.06
      GO TO 523
519   CENT=0.09
      GO TO 523
520   CENT=0.12
      GO TO 523
521   CENT=0.15
      GO TO 523
522   CENT=0.18
523   EXCESS=CENT*(VALUE/4)
      FUND=VISS-EXCESS-FGNT+(VALUE/4)
      WRITE(6,524) EXCESS
524   FORMAT(' ','EXCESSES REDUCED FUND GRANT',F10.2)
      RETURN
      END
```

```fortran
      SUBROUTINE INOUT(IDATA,N,IX4,IX5,INO)
      DIMENSION IDATA(300,25)
      IDUM1=0.1*INO
      DO 600 K=1,IDUM1
      DO 610 I=1,N
      L=I
      IF(IDATA(I,21).EQ.1) GO TO 615
610   CONTINUE
615   IX4=IX4*65539
      R=0.5+IX4*0.2328306E-9
      J=4.0*R+1.0
      IDATA(L,23)=J
      IF(J.GT.1) GO TO 600
      IDATA(L,19)=9999
      IDATA(L,20)=0
      IDATA(L,21)=4
600   CONTINUE
      IDUM2=IDUM1
      DO 620 KK=1,IDUM2
      DO 625 II=1,N
      LL=II
      IF(IDATA(II,21).EQ.0) GO TO 630
625   CONTINUE
630   IX5=IX5*65539
      RR=0.5+IX5*0.2328306E-9
      JJ=4.0*RR+1.0
      IDATA(LL,23)=JJ
      IDATA(LL,21)=3
      IF(IDATA(LL,23).EQ.1) GO TO 631
      GO TO 620
631   IDATA(LL,21)=1
620   CONTINUE
      INO=INO+IDUM2
      RETURN
      END
```

```fortran
      SUBROUTINE REORDR(IDATA,DATA,N,FUND,ITIME,DCLORD)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DCLORD=0.0
      DO 401 I=1,N
      IF(IDATA(I,21).EQ.1) GO TO 402
      IF(IDATA(I,21).EQ.2) GO TO 402
      IF(IDATA(I,21).EQ.4) GO TO 402
      IDATA(I,24)=0
      DATA(I,12)=0.0
      IDATA(I,25)=9999
      GO TO 401
402   IF(IDATA(I,2).LE.IDATA(I,5)) GO TO 403
      IDATA(I,24)=0
      DATA(I,12)=0.0
      IDATA(I,25)=9999
      GO TO 401
403   DO 404 J=1,20
      IOPB=J*IDATA(I,7)
      NQTY=IOPB+IDATA(I,2)
      IF(NQTY.GT.IDATA(I,5)) GO TO 405
404   CONTINUE
405   IDATA(I,24)=IOPB
      DATA(I,12)=DATA(I,1)*IOPB
      DCLORD=DCLORD+DATA(I,12)
      IDATA(I,3)=IDATA(I,3)+IDATA(I,24)
      IDATA(I,25)=ITIME+DATA(I,5)*30.0
401   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RECPT(IDATA,DATA,III,ICQTY,AVISS,KQTR)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION IOQTY(300,8)
      DIMENSION AVISS(4)
      IDATA(III,2)=IDATA(III,2)+IDATA(III,3)
 9058 IF(IOQTY(III,3)=IOQTY(III,2).EQ.0) GO TO 3410
      IDATA(III,25)=IOQTY(III,2)
      IDATA(III,24)=IDATA(III,1)
      DO 3411 I=3,7,2
      K=I+1
      J=I-2
      L=I-1
      IF(IOQTY(III,K).EQ.0) GO TO 3412
      IOQTY(III,J)=IOQTY(III,I)
      ICQTY(III,L)=IOQTY(III,K)
 3411 CONTINUE
      IOQTY(III,8)=0
      IOQTY(III,7)=9999
      GO TO 3413
 3410 IDATA(III,3)=0
      IDATA(III,25)=9999
      GO TO 3413
 3412 IOQTY(III,J)=9999
      IOQTY(III,L)=0
 3413 IF(IDATA(III,4).EQ.0) GO TO 3416
      IDUM3=IDATA(III,2)-IDATA(III,4)
      IF(IDUM3.LT.0) GO TO 3415
      AVISS(KQTR)=AVISS(KQTR)+(IDATA(III,4)*DATA(III,1))
      DATA(III,15)=DATA(III,15)+1.0
      IDATA(III,2)=IDUM3
      IDATA(III,4)=0
      GO TO 3416
 3415 AVISS(KQTR)=AVISS(KQTR)+(IDATA(III,2)*DATA(III,1))
      DATA(III,15)=DATA(III,15)+1.0
      IDATA(III,2)=0
      IDATA(III,4)=(-IDUM3)
 3416 RETURN
      END
```

```fortran
      SUBROUTINE DISSU(IDATA,DATA,JJJ,ICQTY,KQTR,ITIME,IX2,IX3,AVISS,DOL
     1ORD)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION IOQTY(300,8)
      DIMENSION AVISS(4)
      KKKCNT=KQTR+14
      KKKONT=KQTR+10
3365  IDATA(JJJ,KKKONT)=IDATA(JJJ,KKKONT)+1
      IDATA(JJJ,KKKONT)=IDATA(JJJ,KKKONT)+IDATA(JJJ,20)
      DATA(JJJ,16)=DATA(JJJ,16)+1.0
      IDUM4=IDATA(JJJ,2)-IDATA(JJJ,20)
      IF(IDUM4.LE.0) GO TO 3360
      IDATA(JJJ,2)=IDUM4
8088  AVISS(KQTR)=AVISS(KQTR)+(DATA(JJJ,1)*IDATA(JJJ,20))
      DATA(JJJ,15)=DATA(JJJ,15)+1.0
      IDATA(JJJ,20)=0
      GO TO 3361
1773  IX2=IX2*65539
      AA=0.5+IX2*0.2328306E-9
      IDUM8=ALOG(AA)/(-DATA(JJJ,8))
      IF(IDATA(JJJ,19).LE.ITIME) IDATA(JJJ,19)=IDUM8+ITIME
3369  IX3=IX3*65539
      AB=0.5+IX3*0.2328306E-9
      IDATA(JJJ,20)=ALOG(AB)/ALOG(1.0-DATA(JJJ,9))
      IF(IDATA(JJJ,20).GE.1000) GO TO 3369
      IF(IDATA(JJJ,20).LE.0) GO TO 3369
      GO TO 8091
3360  IF(IDATA(JJJ,2).EQ.0) GO TO 3361
      AVISS(KQTR)=AVISS(KQTR)+(DATA(JJJ,1)*IDATA(JJJ,2))
      DATA(JJJ,15)=DATA(JJJ,15)+1.0
      IDATA(JJJ,2)=0
      IDATA(JJJ,20)=(-IDUM4)
3361  DO 3362 I=1,200
      K=I-1
      IDUM5=K*IDATA(JJJ,7)
      IDUM10=IOQTY(JJJ,2)+IOQTY(JJJ,4)+IOQTY(JJJ,6)+IOQTY(JJJ,8)
      IDUM6=(IDUM5-IDATA(JJJ,4))+(IDATA(JJJ,3)+IDUM10)+IDATA(JJJ,2)
      IF(IDUM6.GT.IDATA(JJJ,5)) GO TO 1772
3362  CONTINUE
1772  CCST=IDUM5*DATA(JJJ,1)
      IF(COST.GT.DATA(2,25)) GO TO 1881
      DOLORD=DOLORD+COST
1776  IDATA(JJJ,4)=IDATA(JJJ,4)+IDATA(JJJ,20)
      IF(COST.EQ.0.0) GO TO 1771
      DATA(JJJ,17)=DATA(JJJ,17)+1.0
      DATA(JJJ,13)=DATA(JJJ,13)+1.0
```

```
      IF(IDATA(JJJ,24).EQ.0) GO TO 3359
      DATA(JJJ,14)=DATA(JJJ,14)+(IDATA(JJJ,25)-IDATA(JJJ,19))
3359  GO TO 1771
1771  DATA(JJJ,14)=DATA(JJJ,14)+DATA(JJJ,5)*30.0
      DATA(2,25)=DATA(2,25)-COST
      IF(IDATA(JJJ,3).GT.0) GO TO 3364
      IDATA(JJJ,3)=IDUM5
      IDATA(JJJ,25)=(30.0*DATA(JJJ,5))+ITIME
      GO TO 1773
3364  DO 3366 I=2,8,2
      KKK=I
3366  IF(IOQTY(JJJ,KKK).EQ.0) GO TO 3367
3366  CONTINUE
      IOQTY(JJJ,KKK)=IOQTY(JJJ,KKK)+IDUM5
      GO TO 1773
3367  IOQTY(JJJ,KKK)=IDUM5
      KKT=KKK-1
      IOQTY(JJJ,KKT)=(30.0*DATA(JJJ,5))+ITIME
      GO TO 1773
1744  IDATA(JJJ,4)=IDATA(JJJ,4)+IDATA(JJJ,20)
      GO TO 1773
1881  COST=DATA(JJJ,1)*IDATA(JJJ,20)
      IDUM5=IDATA(JJJ,20)
      IF(COST.GT.DATA(2,25)) GO TO 1774
      GO TO 1776
1774  DATA(JJJ,18)=DATA(JJJ,18)+1.0
      DATA(JJJ,19)=DATA(JJJ,19)+COST
      DATA(JJJ,16)=DATA(JJJ,16)-1.0
      IDATA(JJJ,KKCNT)=IDATA(JJJ,KKCNT)-1
      IDATA(JJJ,KKKONT)=IDATA(JJJ,KKKGNT)-IDATA(JJJ,20)
      IF(DATA(3,25).GT.0.0) GO TO 1773
      WRITE(6,8092) ITIME,DATA(2,25)
8092  FORMAT(' ','TIME OF FUND DEPLETION=',I5,'FUND BALANCE IS',F16.2)
      DATA(3,25)=1.0
      GO TO 1773
8091  RETURN
      END
```

```
      SUBROUTINE ENDQTR(IDATA,DATA,N,SM,QMC,VADSUM,AVISS,FGNT,FUND,VALUE
     1,VISS,KQTR,IX2,IX3,INO,EXCZ,ITIME)
      DIMENSION IDATA(300,25)
      DIMENSION DATA(300,25)
      DIMENSION AVISS(4)
      DIMENSION SM(10)
      DIMENSION QMC(10)
      VALUE=0.0
      IZCOM=KQTR+1
      DO 3374 I=1,4
      VALUE=VALUE+AVISS(I)
3374  CONTINUE
      VISS=0.0
      DO 3375 I=1,KQTR
      VISS=VISS+AVISS(I)
3375  CONTINUE
      IF(KQTR..GT.1) GO TO 133
      WRITE(6,9032) KQTR,FUND
9032  FORMAT(' FUND QTR',I3,3X,'IS',F10.2)
133   CALL BUCKS(DATA,IDATA,VALUE,N,VISS,FGNT,FUND)
      FGNT=FGNT+FUND
      DO 3376 I=1,N
      IF(IDATA(I,21).EQ.0) GO TO 3376
      IF(IDATA(I,21).EQ.1) GO TO 3376
      IF(IDATA(I,21).EQ.2) GO TO 3377
      IF(IDATA(I,21).EQ.3) GO TO 3379
      IF(IDATA(I,21).GE.8) GO TO 3376
      GO TO 3378
3377  IF(IDATA(I,23).EQ.IZOOM) GO TO 3380
      GO TO 3376
3380  IDATA(I,21)=4
      IDATA(I,19)=9999
      IDATA(I,20)=0
      GO TO 3376
3378  IDATA(I,21)=IDATA(I,21)+1
      IF(IDATA(I,21).LT.7) GO TO 3376
      EXCZ=EXCZ+(IDATA(I,2)*DATA(I,1))
      IDATA(I,2)=0
      IDATA(I,3)=0
      IDATA(I,4)=0
      IDATA(I,24)=0
      IDATA(I,25)=9999
      IF(IDATA(I,21).GT.6) INO=INO-1
      GO TO 3376
3379  IF(IDATA(I,23).EQ.IZOOM) GO TO 3381
      GO TO 3376
3381  IX2=IX2*65539
      AAA=0.5+IX2*0.2328306E-9
```

```
      IDUM21=ALOG(AAA)/(-DATA(I,8))
      IDATA(I,19)=IDUM21+ITIME
      IF(IDATA(I,19).LE.ITIME) IDATA(I,19)=ITIME+1
      IDATA(I,21)=1
3382  IX3=IX3*65539
      AAB=0.5+IX3*0.2328306E-9
      IDATA(I,20)=ALOG(AAB)/ALOG(1-DATA(I,9))
      IF(IDATA(I,20).GE.10000) GO TO 3382
      IF(IDATA(I,20).LE.0) GO TO 3382
3376  CONTINUE
      WRITE(6,134)KQTR,EXCZ
134   FORMAT(' ','EXCESS AT END QTR',I3,3X,'IS',F10.2)
      KQTR=KQTR+1
      WRITE(6,9032) KQTR,FUND
      RETURN
      END
```

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10. CDR. J. P. Dowling, SC, USN   1
    Operations Analysis Branch
    Ships Parts Control Center
    Mechanicsburg, Pennsylvania   17055

11. CDR. P. F. McNall, SC, USN   1
    Code 94
    Fleet Material Support Office
    Mechanicsburg, Pennsylvania   17055

12. LCDR J. U. Dell, SC, USN   1
    Code 97
    Fleet Material Support Office
    Mechanicsburg, Pennsylvania   17055

13. LCDR R. D. Perkins, SC, USN   1
    SUP 04511
    Naval Supply Systems Command
    Washington, D.C.

14. LCDR R. E. Lewis, SC, USN   1
    Naval Supply Center
    937 North Harbor Drive
    San Diego, California   92132

15. LCDR E. L. Barnes   1
    Code 51
    Naval Supply Center
    937 North Harbor Drive
    San Diego, California   92132

16. LCDR E. J. Shields   1
    Naval Supply Center
    Norfolk, Virginia   23512

17. LCDR W. T. Lee   1
    Naval Supply Center
    Oakland, California   94625

18. CDR J. R. Davis   1
    Code 6300
    Naval Air Station
    Point Mugu, California   93042

19. LCDR F. L. Meyer   1
    Naval Supply Center
    Charleston, South Carolina   29411

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Control in the management of stocks of retail material (DSA) at Navy stock points is exercised through a centrally administered stocking policy model (VOSL) and funding policy. The dynamic behavior of these controls operating on a stock point was investigated by computer simulation. The simulation results indicate that under the most favorable circumstances, the value of resupply orders directed by the VOSL stocking model exceeded

(20. ABSTRACT continued)

the grants made by the funding policy. Under less favorable,
more realistic conditions, the difference between funding
requirements and funding grants is more marked and supply
performance degrades very significantly over time. The funding
dilemma investigated in this study is well known to Navy stock
points and they have devised various ways of attempting to deal
with it. Significantly, even in a climate of insufficient
funding, system stock policies (VOSL) provide better performance
than locally devised policies.